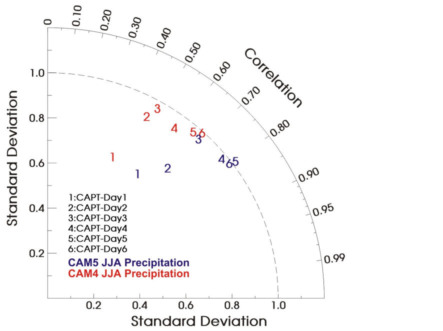
Metrics and Diagnostics for Climate Model Short-Range Hindcasts

Research Highlight

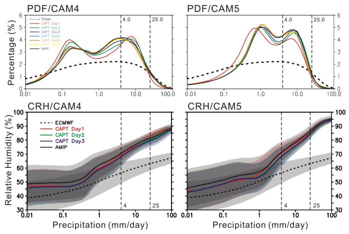
Despite recent advances made in climate modeling, large systematic biases are still present in the models' simulated mean state of climate. However, fully understanding the cause of these systematic biases is difficult because of the complexity of the climate system. Scientists at Lawrence Livermore National Laboratory (LLNL) have used the U.S. Department of Energy (DOE)-funded Cloud-Associated Parameterizations Testbed (CAPT) to systematically examine the relationship between composite biases in the short-range hindcasts and long-term climate simulations exhibited in the latest versions of the Community Atmospheric Model, Version 4 (CAM4) and Version 5.1 (CAM5).

A series of 6-day hindcasts was conducted with CAM4 and CAM5 for the Year of Tropical Convection period (May 2008–April 2010). Several metrics and diagnostics were proposed and implemented with the goal of systematically exploring and diagnosing climate model biases in short-range hindcasts, and to quantify how fast hindcast biases approach to climate biases with an emphasis on tropical precipitation and associated moist processes. The metrics proposed in this study are precipitation mean bias, root mean square (RMS) errors, pattern correlations, spatial standard deviations, and bias correspondence. The diagnostics are stratiform fraction of precipitation, probability density function (PDF) of daily precipitation intensity, composites of column water vapor (CWV), column relative humidity (CRH, also known as saturation fraction), temperature, and specific humidity profiles as a function of precipitation intensity, as well as composites of stratiform rainfall fraction as a function of CRH. Based on these metrics and diagnostics, initial drifts in precipitation and associated moisture processes can be identified in the hindcasts, and the biases share great resemblance to those in the climate runs ("fast-processes").

Compared to observations, model hindcasts produce too high a probability of low- to intermediate-intensity precipitation at daily time scales during northern summers, which is consistent with too-frequently triggered convection by its deep convection scheme. For intense precipitation events (> 25 mm day-1), however, the model produces much lower probability because the model requires much higher column relative humidity than observation to produce similar precipitation intensity as indicated in the diagnostics. These analyses demonstrate the usefulness of these metrics and diagnostics to diagnose climate model biases in numerical weather prediction mode.



Pattern statistics of precipitation biases from both CAM4 and CAM5 hindcast runs. The reference fields are the correspondent biases in the AMIP runs, and the data are analyzed over 0°–360°, 20°S–20°N.



Daily precipitation PDF and composites of daily column relative humidity as a function of precipitation intensity from ECMWF-YOTC Analysis/TRMM 3B42, as well as from CAM4 and CAM5 hindcasts and AMIP simulations. The data are analyzed over 0°–360°, 20°S–20°N.

Reference(s)

Ma H, S Xie, JS Boyle, SA Klein, and Y Zhang. 2012. "Metrics and diagnostics for precipitation-related processes in climate model short-range hindcasts." Journal of Climate, , . ACCEPTED.

Contributors

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Cloud Life Cycle